PHYSICS AND SOVIET–WESTERN RELATIONS IN THE 1920s AND 1930s

After seven years of isolation brought about by world war and the Russian Revolution, Soviet physicists rejoined the international scientific community in the early 1920s, only to have these contacts restricted again under Stalin.

Paul R. Josephson

The recent intensification of Soviet interest in participating in international scientific activities is not merely a result of new policies introduced under Mikhail Gorbachev. Soviet scholars have sought out contacts with Western scholars since the first years of the Russian Revolution, although under Joseph Stalin and during times of heightened political tensions with the West these contacts have been reduced. On the eve of the revolution, the Russian empire had no more than a hundred physicists—including professors, docents and laboratory assistants with the equivalent of graduate degrees, but not including primary- or secondary-school teachers—and very few well-equipped laboratories. While creating conditions propitious to the long-term growth of physics as a dispcipline, the revolution led to short-term disruptions of research. Making matters worse, World War I cut physicists off from their customary contacts with Western scholars and laboratories, and the 1918–20 civil war between the Reds (the Bolsheviks and their allies) and the Whites (the monarchists and their sympathizers) atomized the domestic physics community.

This article examines how Soviet physicists reestablished scientific relations with the West during the 1920s after almost eight years of isolation, and how in the 1930s, under Stalin, Soviet scholars once again lost those vital scientific ties they had worked so hard to resurrect. The story involves many great physicists, including:

▷ Lev Davidovich Landau, the greatest Russian theorist of the 20th century. Landau obtained first-rate results in virtually every area of theoretical physics, ranging from quantum electrodynamics to solid-state physics. He was the author with Evgenii Mikhailovich Lifshitz of an internationally known series of texts on theoretical physics.

▷ Petr L. Kapitsa, who worked under Ernest Rutherford at the Cavendish Laboratory in Cambridge, England, and after returning to Russia worked on high magnetic fields, superconductivity, superfluidity and other areas of low-temperature physics at the Institute of Physical Problems, which was created for him in 1937. Kapitsa designed liquefiers for helium and other gases, and created the Soviet liquid oxygen industry.

▷ Sergei I. Vavilov, head of the department of physical optics at the Institute of Physics and Biophysics in the 1920s, then scientific director of the State Optical Institute and later president of the Soviet Academy of Sciences. It was under Vavilov's guidance that Pavel A. Cherenkov did his work on radiation from electrons moving quickly through matter.

▷ Nikolai N. Semenov, deputy director of the Leningrad Physico–Technical Institute, then director of the Institute of Chemical Physics and vice president of the Soviet Academy of Sciences, and one of the founders of chemical physics.

▷ Abram Feodorovich Ioffe (pictured on page 57), founder

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Talking physics on the Volga in 1928 during the sixth congress of the Russian Association of Physicists are (from left to right) Paul Dirac from England, Iakov I. Frenkel' of the Soviet Union and Alfred Lande from Germany. The general makeup and program of the congress reflected the youthful vitality of Soviet physics and the growing international respect accorded Soviet physicists. Much of the congress was held during a steamship trip down the Volga, in an atmosphere that promoted free discussion of controversial questions of contemporary physics.

of the Leningrad Physico–Technical Institute, which became the leading Soviet physics institute between the two world wars, and organizer of the Russian Association of Physicists. Ioffe, the dean of Soviet experimental physics for many years, worked on the physics of semiconductors and the electrical, mechanical and other properties of crystals.

▷ Iakov I. Frenkel' (shown in the photo above), a leading theorist of the early Soviet period whose work covered the electronic theory of solids, quantum mechanics, magnetism, the physics of liquids and nuclear physics.

War, revolution and isolation

World War I and the revolution isolated Russia from other countries, created shortfalls of materials, supplies and reagents, disrupted publication and interrupted regular government funding for scientists. The Czar had abdicated in February 1917, and physicists met with little success in getting Alexander Kerensky's provisional government to turn attention to these difficulties. The Bolshevik coup in October initially made matters worse. Throughout the winter of 1917–18, as research and living conditions grew ever more precarious, physicists, who had sought to avoid political involvement, opened formal talks with the new government. By the spring of 1918 attendance at periodic meetings of the physics section of the Russian Physico–Chemical Society had dropped to 25, less than half the normal figure. With sources of support dwindling and cold and hunger taking hold of Leningrad, physicists approached Anatoli V. Lunacharskii, Commissar of Enlightenment, for financial support. They needed funding for all areas of the physics enterprise: publications, congresses and the several newly founded physics institutes. By the end of March, the physicist Orest D. Khvol'son had secured emergency publication subvention from Lunacharskii, but this went little beyond short-term needs. Leading Soviet scholars, and particularly those in the Leningrad physics community, therefore began to work through a newly founded organization, the Russian Association of Physicists, to lobby the government for the financial resources necessary to reopen domestic and international scientific contacts.

Publication of major Soviet physics journals, 1917–23

	Number of journals published	Total number of issues
1917	1	3
1918	2	7
1919–20	3	12
1921	1	2
1922	3	9
1923	2	7

Standing at the forefront of this effort was Ioffe, who enlisted the help of Dmitrii S. Rozhdestvenskii, founder of the State Optical Institute, Khvol'son and Aleksei N. Krylov from the Soviet Academy of Sciences. In 1919 they and other Leningrad and Moscow physicists had organized the Russian Association of Physicists to attack the problems that frustrated development of the nascent discipline. The group was set up as an adjunct to the physics section of the Czarist-era Russian Physico–Chemical Society, a body of some 200 members, and soon took its place. The association pressed the Bolshevik government to support research and publication. There was a critical need for materials and apparatus from abroad because Russia's factories were as yet unable to produce them.

At its first congress, held on the 50th anniversary of the Mendeleev periodic chart in February 1919, in what a report in the *Journal of the Russian Physico–Chemical Society* called a "melancholy Leningrad of iced-over buildings without food or heat or the promise of reimbursement of expenses," the Russian Association of Physicists established a committee of four—Ioffe, Krylov, V. A. Anri and Petr P. Lazarev, a Moscow physicist who founded the Institute of Physics and Biophysics—to coordinate the receipt of foreign literature, instruments and equipment, and to resurrect foreign research travel. They called for government support for new institutes, reestablishment of ties between physicists in Russia and abroad, and resumption of publication. Physicists at the congress also discussed such diverse topics as the Bohr model of the atom, optics, spectrography, relativity and quantum theory.

Members of the association encountered significant difficulties in following through on their professional mandate. During the 1921–22 academic year, the position of the association deteriorated. It lost government funding and had to turn to its 17 institutional members for support. At national congresses in Moscow in 1920, in Kiev in 1921 and in Nizhnyi Novgorod in 1922, the association discussed the continuing scientific and organizational challenges to the discipline, but it failed until the fourth congress in Leningrad in 1924 to achieve the national flavor and strength it had desired from the start.

The major Soviet physics journals of the time were the following:

▷ *Zhurnal Russkogo Fiziko–Khimicheskogo Obshchestva*, or *Journal of the Russian Physico–Chemical Society*; in 1931 the physics section of this journal became *Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, or *Journal of Experimental and Theoretical Physics*.

▷ *Vestnik Rentgenologii i Radiologii*, or *Herald of Roentgenology and Radiology*, which appeared for three issues before ceasing publication.

▷ *Uspekhi Fizicheskikh Nauk*, or *Successes of the Physical Sciences*.

▷ *Trudy Gosudarstvennogo Opticheskogo Instituta*, or *Works of the State Optical Institute*.

▷ Academy of Sciences publications such as *Doklady*, or *Reports*, and *Izvestiia*, or *Proceedings*.

Between 1917 and 1923 these physics journals were published irregularly, as the table at the top of this page indicates. The receipt of 50 tons of paper from the United States in 1921 helped reestablish Academy of Sciences publications, although problems persisted until 1924.

Reestablishing ties with the West

Although Russian physicists made progress in the domestic organization of physics research and publication after the revolution, their international isolation continued to be a pressing concern until the mid-1920s. With the end of the civil war in 1920, scientists turned to the government for approval of foreign travel for research and for funds to purchase instruments, books and journals. In petitioning the Commissariat of Enlightenment about "the necessity of foreign travel for scholars for scientific purposes," physicists emphasized the international character of science, which "demanded uninterrupted interaction" of scholars of all countries.

Ioffe assumed a prominent role in this process. He had studied with Wilhelm Röntgen for three years in Munich, where he used x rays to investigate the mechanical strength of quartz crystals. In 1906 he returned to St. Petersburg. There he developed a close friendship with Paul Ehrenfest, who taught at Petersburg University from 1907 to 1912 before taking over Hendrik A. Lorentz's chair in physics at the University of Leiden. Ioffe wrote Ehrenfest in the summer of 1920, asking him to help Soviet scholars catch up on recent developments in the West by sending important recent books to Ioffe through an address in Finland. Ehrenfest did what he could, but could not single-handedly reestablish scientific relations. Soviet physicists needed above all else firsthand contact with Western achievements.

In February 1920 physicists in Leningrad had requested approval from the Main Scientific Administration of the Commissariat of Enlightenment to send the radiologist Mikhail I. Nemenov and Ioffe abroad. The commissariat approved the request, but two problems remained. First, it was necessary to establish diplomatic relations with a Western country to get visas. The USSR established diplomatic relations with Germany in 1922 and with the rest of Europe only after 1924. Second, because the Bolshevik government had canceled all Czarist debt obligations, only hard currency would suffice for foreign purchases. Ioffe was abroad from February through August of 1921 and again from April through September of 1922, and corresponded with his wife in Leningrad during these periods. The letters are extant and reveal the successes Soviet physicists encountered in establishing foreign contacts in the face of the many problems.

Ioffe in Western Europe

On his first trip, Ioffe spent two weeks in Estonia waiting for visas to Holland, Sweden and Germany. He received only the last one. By the end of March he had made it to Berlin and ordered 391 journal subscriptions, for three- to five-year periods, and 350 books, but he was still waiting

for Kapitsa to arrive with the letters of credit for these purchases. A large number of the books and journals ordered never arrived; journal subscriptions received at the Leningrad Physico–Technical Institute library in fact dropped from 54 in 1922 to 42 in 1925 and 36 in 1926. While in Berlin, Ioffe gave lectures at several physics colloquia, to which Max Planck, Walter Nernst and others reacted favorably. To Ioffe's delight, Ehrenfest arrived in Berlin in April to renew their friendship, discuss issues in physics and plan how to normalize Soviet scientific exchanges with the West. These personal successes only somewhat buoyed Ioffe's spirits in light of the continued difficulties in Moscow in getting the Commissariat of Enlightenment to release the promised funds; Frenkel' was hard at work trying to solve this problem. When Ioffe finally received the letters of credit in May, he completed a number of transactions and sent 2.4 million deutsche marks of instruments and machine tools, 60 000 DM of chemical products and a spectrograph to the Leningrad Physico–Technical Institute.

In June Ioffe journeyed to England and met with Rutherford, William and Lawrence Bragg and others, and finally met up with Kapitsa. Once again, however, uncertainties over letters of credit dogged his every step. Ioffe expressed particular displeasure at how the government had delayed funds. Nonetheless, Ioffe secured in Britain another eight boxes of books and instruments, including five Coolidge tubes and kenetrons (a type of vacuum tube) costing £7738 sterling. His meetings with Rutherford and the Braggs were particularly successful; among other things, they helped him to arrange publication of an article in *Nature*. In July he returned to Leningrad by way of Berlin, Hamburg and Leiden.

During his second trip abroad, in 1922, Ioffe succeeded in procuring another 100 boxes of equipment, including two powerful 200-kV transformers, string galvanometers and a Siemens oscillograph. While in Berlin, Ioffe met with Karl Wagner, Arnold Sommerfeld, Wilhelm Wien, Kasimir Fajans and Walter Gerlach. A meeting with physicists in Göttingen proved fruitful to Ioffe's efforts to

Abram Feodorovich Ioffe and his wife, Anna Vassilievna Ioffe. Ioffe, the dean of Soviet experimental physics in the 1920s and 1930s, was instrumental in reestablishing contacts with Western scholars after World War I. He founded the Leningrad Physico-Technical Institute, which became the leading Soviet physics institute between the two world wars. (Photograph from Peter H. Plesch.)

reestablish normal scientific exchanges with his European colleagues: The German physicists agreed to send to the Leningrad Scholars' Club several copies of reprints of all German articles in the main physics journals dating back to 1914, and one German scientist agreed to organize a center for the selection of individual reprints of scientific work to send to Russia.

By 1924 foreign contacts were an integral part of Soviet research and an indispensable source of scientific equipment. In that year the Optical Institute's Rozhdestvenskii traveled with $80 000 to Europe, where he purchased instruments that, as a colleague recalled, "opened the possibility of beginning systematic production of optical glass in [a Russian] factory." The Soviet Union opened a special customs point to receive the hundreds of boxes of scientific materials sent to the optical institute. During the 1923–24 academic year Ioffe, Aleksandr A. Chernyshev, Kapitsa and others represented the Leningrad Physico–Technical Institute abroad; the government had by then granted Ioffe's institute a monthly allowance of 1000 rubles for foreign purchases. The institute had also signed the first of a number of contracts with foreign firms for research and development. By 1926 one-fifth of all institute physicists had visited Western physics facilities, although younger scholars, who might have benefited the most from such visits, were excluded from foreign travel.

The Academy of Sciences played a major role in reestablishing international scientific contacts. Three of the 10 scholars sent abroad in 1920 were academicians, as were 8 of the 17 in 1922, 12 of the 25 in 1924 and 15 of the 44 in 1926. Such leading figures as academy president Aleksandr P. Karpinskii, geochemist Vladimir I. Vernadskii, Krylov, geologist Aleksandr E. Fersman and physiologist Ivan P. Pavlov traveled to the West in the first difficult years. The 200th-anniversary celebration of the Academy of Sciences, held in September 1925 and attended by over 120 scientists from Austria, England, Germany, Holland, India, Spain, Italy, the US and France, was especially important to the normalization of scientific ties; academy scientists and government officials used the event to make professional contacts with foreign researchers more acceptable from a political, economic and ideological standpoint.

In the 1927–28 academic year there were almost 400 foreign trips under government auspices, and 11 of these were to the United States. By the next year, however, the number of trips fell to 140. Physicists at Ioffe's institute in particular seem to have benefited from the normalized contacts. Among the almost 40 Soviet physicists who visited Europe and the US were Iurii A. Krutkov, Landau, Vladimir A. Fok, Iurii B. Rumer, Kapitsa, Frenkel' and Ioffe himself.

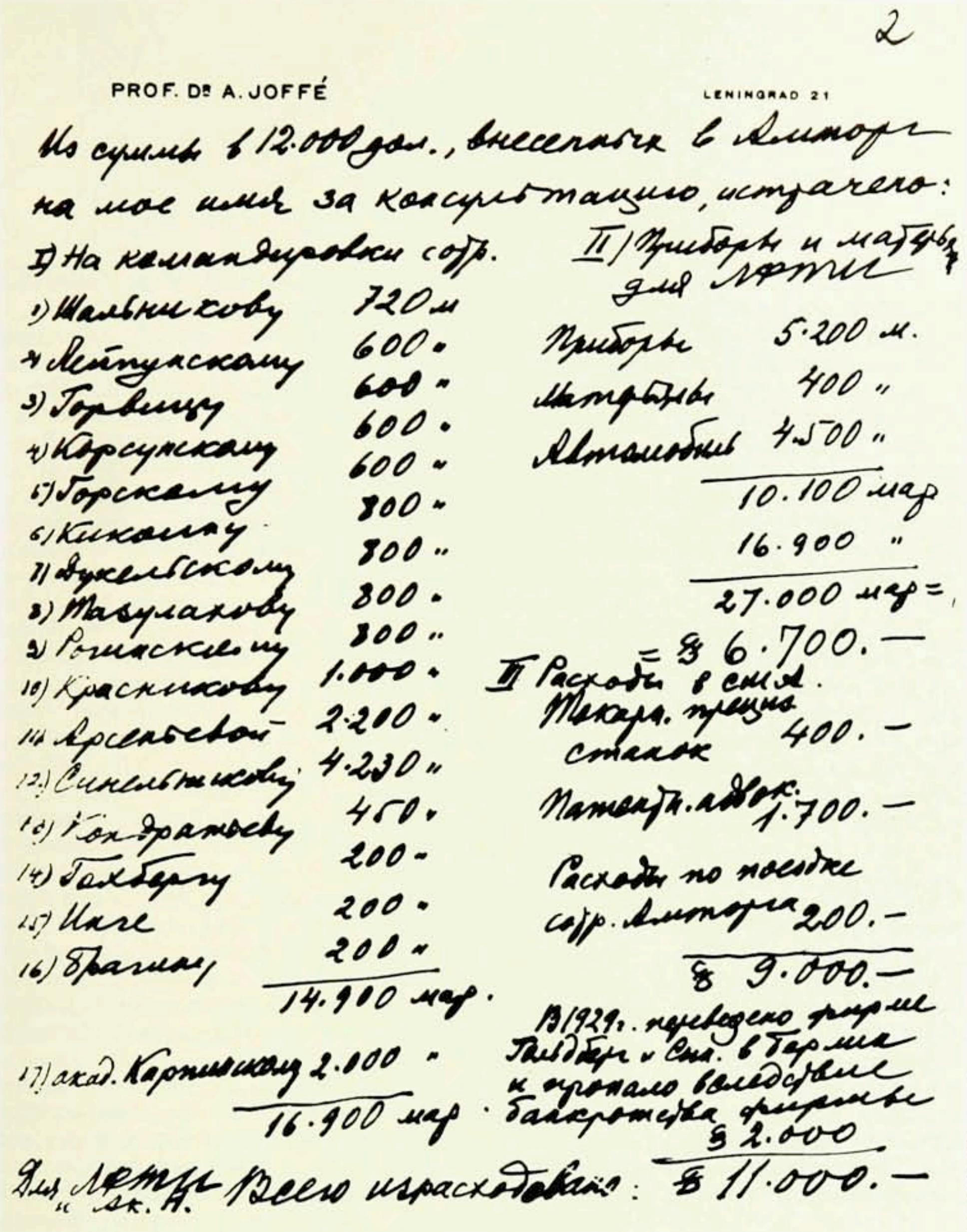
In the mid-1920s Soviet scholars participated more and more frequently in the international scientific arena, studied at German, American and British universities, and attended such prestigious gatherings as the international Solvay meetings in Brussels. These activities had a positive impact on Russian physicists in three ways. First, Russian physicists often based their ideas for the creation and organization of new research institutes on such examples of university and industrial physics laboratories as the Physikalisch–Technische Reichsanstalt, MIT, Harvard, Berkeley, Caltech, General Electric and Westinghouse. Second, contacts with Western firms resulted in research contracts that brought in hard currency. Third, the contacts gave Soviet scholars the opportunity to exchange ideas with their Western counterparts, primarily through study sponsored by the International Education Board.

Frenkel' and the IEB

The IEB, which was funded by the Rockefeller Foundation, operated between 1923 and 1938, but was most active in the period 1923–28. Through the IEB Soviet scholars strengthened their ties with foreign scholars and brought back scientific instruments and ideas for their laboratories, as the experiences of Frenkel' and Ioffe demonstrate. Ehrenfest was instrumental in getting the IEB to support physicists. In March 1925 Augustus Trowbridge, IEB's director for Europe, met with Ehrenfest in Leiden about Ehrenfest's plans to get "a few of the more gifted young Russians into Western Europe." Ehrenfest recommended Krutkov and Frenkel' on the grounds that "one will be doing the most that one can for this branch of science in Russia at the present time since these men will go back with new ideas gained by researching for a year in the West." Trowbridge supported Frenkel' 's candidacy because of his impressive publication record.

In his application to the IEB, Frenkel' expressed his desire to work in Göttingen with Max Born on "the electronic theory of solid and liquid bodies" and "general electrodynamics in connection with the quantum theory" before traveling to Cambridge for a few months. He hoped to obtain results "regarding the nature and magnitude of attractive and especially repulsive forces between atoms, and, further, to extend the theory [to] liquid bodies, the liquid state of matter . . . being much nearer to the solid than the gaseous one." Frenkel' also proposed to "show that the electron must be considered as spatially unextended force centers." The IEB approved Frenkel' 's candidacy, funds for travel and a monthly allowance of $182 for Frenkel' and his wife.

When Frenkel' arrived in Berlin in November 1925, however, he found that Born had already departed to deliver a course of lectures at MIT. After consulting with Ehrenfest and Ioffe, Frenkel' left for Hamburg to study with Wolfgang Pauli and Otto Stern, making plans to return to Berlin to work with Albert Einstein and finally in the spring or summer to go to Göttingen with Born. He also consulted with Paul Langevin and Leon Brillouin in Paris. Frenkel' 's European sojourn had a twofold importance for Soviet physics. First, it served to cement ties with European theoreticians, to convince them of the high quality of research going on in the Soviet Union and to pave the way for such scholars as Landau, Petr I. Lukirskii, Viktor R. Bursian and George Gamow to follow him to their laboratories. Second, when Frenkel' returned to the Leningrad Physico–Technical Institute he was better prepared to provide first-rate leadership to a new generation of theoreticians in Leningrad: Fok, Georgii A. Grinberg and Dmitrii D. Ivanenko, and in the 1930s Matvei P. Bronshtein and Lev V. Rozenkevich, both of whom perished in Stalin's purges. Frenkel' went abroad



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PROF. Dr A. JOFFÉ — LENINGRAD 21

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Budget. This was Ioffe's plan for using the hard currency that he raised through contracts with Western firms. Listed are 17 scholars, mostly from his institute; they would use the money for foreign research travel.

again in 1930–31, primarily to the University of Minnesota, and upon his return contributed to the development of quantum mechanics in the USSR.

Ioffe at Berkeley

European scholars received Ioffe as an honored guest; they were relieved to see international scientific relations return to normal. His stories of what Soviet physics had achieved in isolation in less than a decade impressed them. Ioffe, for his part, gained confidence that his institute was moving along the right path, and welcomed the recognition he was getting for his work.

Ioffe traveled in the US and Europe several times during the 1920s, having first helped to reestablish regular scientific exchanges with European scholars in 1920. From November 1925 to February 1926 he visited Berlin, Paris and the United States. In the US he visited Columbia University, the Rockefeller Institute, the cities of Chicago, Madison, Boston, Kansas City and Pasadena, and en route visited GE and Westinghouse. These visits influenced his views on the organization of industrial research and development, especially in regard to their grand scale.

In January 1927 Ioffe went abroad for his most successful trip. He gave a series of lectures at Harvard and MIT and then traveled to Schenectady, Washington and Pittsburgh, where he participated in colloquia. The General Electric facilities in Schenectady especially drew his interest: Ioffe was impressed by the company's 400-kV Coolidge tubes with 40-cm spheres; he also discussed shears and displacements with Irving Langmuir. Ioffe traveled to Berkeley in February for a semester of teaching. He developed a close working relationship with Gilbert Lewis and Leonard Loeb and wrote *Physics of Crystals* during this time. The University of California awarded Ioffe an honorary PhD and paid him the compliment of offering him a professorship, a position Ioffe chose to decline.

After leaving the University of California, Ioffe stopped in New York and Boston, where he negotiated an agreement with Vannevar Bush and L. Marshall to develop and manufacture thin-sheet insulation with the potential backing of up to $50 million from T. J. Coolidge and J. P. Morgan. This was one of many new ventures for

the newly established Raytheon Corporation, through which Ioffe would get a salary of $12 000, certain patent rights and royalties in exchange for development of the insulation. (The budget in the figure on page 59 shows how Ioffe planned to spend the anticipated income and salary.) Ioffe also negotiated with a consortium of German electrotechnical companies, including Siemens AG, to create a laboratory for the production of insulation, obtaining a contract that guaranteed him 10 million DM and 7 percent royalties. Ioffe used the funds received by the end of the summer of 1928 "for my collaborators and pupils being sent to Europe. All together there are 25 physicists from my institute abroad."

Although Ioffe and his institute failed to deliver on the Raytheon contract, Ioffe, Frenkel' and other physicists from the Leningrad Physico–Technical Institute had by the end of the 1920s succeeded in something more important: reestablishing scientific ties with European and American physicists. Many of the achievements of Soviet physicists in the international arena were the result of the successes of the Russian Association of Physicists on the domestic front.

The Russian Association of Physicists

During the period of the New Economic Policy in the mid-1920s, the Russian Association of Physicists grew in membership, national influence and reputation abroad. More than 600 individuals attended the association's fourth congress in Leningrad in 1924, where participants discussed the controversy over the wave and corpuscular theories of light, which was solved with the development of quantum mechanics. At the fifth congress, held in Moscow in 1926, discussions centered on the new physics—Louis DeBroglie's wave mechanics—and its implications for understanding the atomic and molecular properties of matter.

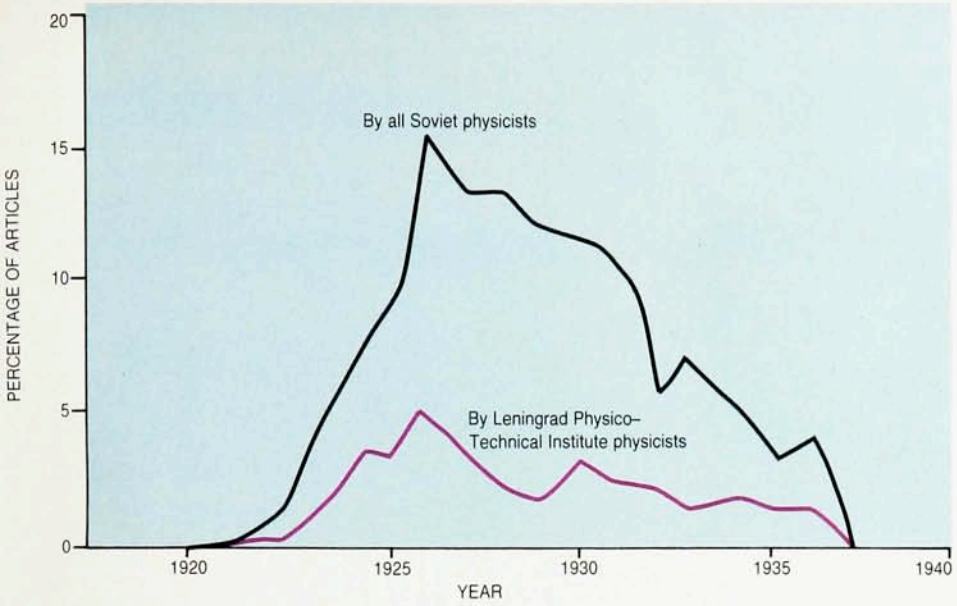
At Ioffe's suggestion, the next conference was held during a steamship trip down the Volga, without the press of the crowds but with freely held discussions on controversial questions of contemporary physics. (See the photograph on page 55.) The sixth congress, in 1928, began with a four-day meeting at the Moscow Scholars' Club, after which the attendees boarded a train to Nizhnyi Novgorod and then proceeded down the Volga on the steamship "Aleksei Rykov" to Tsaritsyn, stopping in the university towns of Nizhnyi, Kazan' and Saratov for meetings and popular lectures with local teachers and students. The general makeup and program of the sixth congress reflected a youthful and vital discipline and the growing international respect that Soviet physicists commanded. Vavilov described the international flavor: "Within the walls of a former seminary in Nizhnyi an English speech with American pronunciation on the thermodynamics of chemical processes was heard (Lewis); in the packed conference hall of Kazan' University the physics of crystals was discussed in a number of languages . . . ; in Saratov Born drew matrix tables on a blackboard." Throughout it all Ioffe could be heard translating from Russian to English or German and back again. The steamboat trip symbolized the feelings of internationalism, corporate spirit and independence that Soviet physicists developed in the 1920s.

In an effort to ensure scientific priority and expand their participation in the international affairs of science, Soviet physicists submitted articles to a number of Western publications, particularly the major German physics journal, *Zeitschrift für Physik*. Before 1923 and the end of international scientific isolation, almost no Soviet physicists published in that journal. Then, after Ioffe and others reestablished Western contacts, a period of rapid and regular increase in the percentage of Russian articles published followed, reaching a peak of 16 percent in 1926 and averaging almost 12 percent for the period 1924–31. All in all, between 1920 and 1936, Soviet scholars wrote 8.5 percent of the 6962 articles published by the journal. With the appearance of a German-language Soviet journal, *Physikalische Zeitschrift der Sowjet Union*, in 1932, the number of articles published in *Zeitschrift für Physik* began to decline. *Physikalische Zeitschrift der Sowjet Union* was intended to communicate to the European community the ideas of Russian scientists, including those in the dialectical materialist philosophy of physics; to ensure Russian priority in discoveries; and, as Ioffe wrote in the foreword to the first volume, "to become the central publication organ of Soviet physics." The pressure for autarky, or self-sufficiency, in science also influenced Soviet physicists not to publish abroad. In protest against Nazism, Soviet physicists ceased to publish in the German physics journal altogether, as the figure on page 61 shows.

By the end of the 1920s Soviet physicists had become fully active in the international arena. They traveled abroad to purchase instruments, chemicals, books and journals and reequipped their laboratories to embark on research at the cutting edge of such areas as the physics of crystals. Under the leadership of Frenkel', Kapitsa, Semenov and Ioffe, they had reestablished scientific ties with the West. Russian physicists took advantage of sabbatical stays in American and British universities, engaged European and American physicists at international congresses and published widely in foreign journals. But policies introduced under Stalin in the late 1920s and 1930s were to reverse many of these achievements.

The Stalin era

During the rapid industrialization, forced collectivization and cultural revolution under Stalin, so-called bourgeois specialists—scientists, technologists and engineers—came increasingly under attack. "Cultural revolution" involved the advancement of workers into positions of responsibility on the basis of class origin or party membership rather than according to traditional definitions of merit, and also entailed "class war" directed against the specialists by an increasingly militant and proletarian Communist Party. Two show trials—the Shakhty and Industrial Party affairs—signaled an end to the autonomy of scientists. Additionally, Stalinist policies toward science required greater emphasis on the applicability of results, centralization of the administration of research and development, the introduction of long-range planning and increasing



Articles by Soviet scholars in *Zeitschrift für Physik*, 1920–36, as a fraction of all articles in the journal.

autarky in science. As physicists left the sixth congress of the Russian Association of Physicists in 1928, they did not realize they would meet together only one more time as a national professional organization. The boat ride down the Volga had symbolized the independence of Soviet physicists. However, to an increasingly class-conscious party in Stalin's Russia, it signified physicists' elitism and detachment from government economic and political programs.

The pressure for autarky in the economy was mirrored in science, with the result that physicists were caught between countervailing forces. They had expended great effort reestablishing scientific ties with the West, knowing the importance of those ties in promoting currency in the selection of research topics and in verifying that work was on the right path. Now, however, for both political and philosophical reasons physicists were pressured to conduct research divorced from the West. The pressure was political, because physicists had to demonstrate that Soviet science could outdistance capitalist science, and philosophical, because they were required to reject a number of contemporary (and in many cases correct) theories of such "idealists" as Niels Bohr and Erwin Schrödinger. During the purges of the 1930s scholars had to protect themselves from unfounded charges of collusion with "enemies" of the Soviet Union. The academic councils of institutes voted to take responsibility for sending reprints to Western physicists, whereas before individuals had felt safe sending reprints themselves. Physicists felt obliged to indicate carefully and pointedly that requests from abroad were unsolicited. For Stalinist ideologues, success under these conditions would demonstrate the superiority of socialist science and secure the motherland from dependence on the West.

Soviet physicists were able to blunt the impact of autarky to a small degree. A few foreign scholars—Bohr, Langevin, Frédéric Joliot-Curie and Wolfgang Pauli, among others—managed to attend physics conferences held in the USSR throughout the 1930s and well into the 1950s. Of course, the institutes continued to subscribe to a large number of Western scientific journals. Largely, however, physicists had to abandon their foreign contacts. The number of Soviet scientists who traveled to the West dropped precipitously in the early 1930s, and although exact numbers are not available, they probably could be counted on a few hands. In one well-known case, Kapitsa, working in Cambridge with Rutherford, returned to the USSR for his annual summer visit. Because the authorities wanted him to help establish low-temperature physics firmly as a field of research and to produce liquid oxygen for a number of applications, he was not allowed to return to his equipment and research in England. The number of physicists coming from Europe also declined. Only in the late 1950s, during de-Stalinization, would autarkic pressures abate to any degree and would Soviet physicists again participate in the international scientific enterprise as they had in the 1920s.

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I would like to thank the International Research Exchanges Board and the Fulbright–Hays program for supporting the research that led to this article, and I would like to thank the referee for helpful comments. I used archival materials at the Leningrad Physico–Technical Institute, the manuscript division of the Saltykov–Shchedrin State Library in Leningrad, the Rockefeller Foundation International Educational Board, the University of California at Berkeley and MIT.

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